

Characteristics of Genitourinary Injuries Associated With Pelvic Fractures During Operation Iraqi Freedom and Operation Enduring Freedom

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ABSTRACT Objectives: Pelvic fractures are markers of severe injury and are often associated with lower genitourinary injuries. The purpose of this study was to investigate the incidence of lower genitourinary injuries and complaints associated with pelvic fractures sustained in combat among nonsurvivors and survivors. Methods: The Armed Forces Medical Examiner System and The Joint Theater Trauma Registry databases were searched to identify survivors and nonsurvivors who sustained a pelvic fracture in combat in 2008. Survivor and autopsy data consisted of injury mode and mechanism and associated organ and extremity injuries. Pelvic fractures were classified using the Tile system. Results: The database search yielded 91 nonsurvivors and 10 survivors with pelvic fractures. Forty-one patients (40%) sustained 61 genitourinary injuries. The majority of genitourinary injuries in nonsurvivors were associated with Tile C pelvic fractures (70%). Twenty percent of survivors had genitourinary injuries, all of which were associated with Tile A fractures. Conclusions: A higher incidence of genitourinary injuries in patients with combat-related pelvic fractures (60%) was found than that of their civilian counterparts. Of the survivors, 100% of those with genitourinary injuries were being treated for erectile dysfunction at their last follow-up. Continued collaboration between orthopaedic surgeons and urologist is needed to address these concurrent injuries.

INTRODUCTION

Pelvic fractures are markers of severe injury and are often associated with major intra-abdominal injuries, hemorrhage, and extremity trauma. The intimate relationship of the lower genitourinary structures with the bony pelvis makes these organs highly vulnerable to injury with pelvic fractures. Civilian trauma literature cites the incidence of genitourinary injuries associated with a pelvic fracture to be between 4% and 15%.^{1–3} The mechanism of injury in these studies is most commonly blunt because of motor vehicle collisions (MVCs), falls, and pedestrian versus auto.^{4,5}

In contrast, combat-related pelvic fractures are often secondary to a blast or explosive projectile mechanism. Injury results not only from the blast wave but also from the penetrat-

ing fragments. The conventional blunt mechanism of pelvic fractures sustained in combat results in a higher mortality rate than the civilian counterparts.⁶ These high-energy characteristics make combat-related pelvic fractures and their associated injuries a complex problem for the treating orthopaedic surgeon. Recent military studies have demonstrated a high rate (99%–100%) of associated organ system injury with combat-related pelvic fractures.^{6–8} Of which, genitourinary injuries have been identified in up to 60% of survivors with an open pelvic fracture secondary to a blast injury.⁸ In addition, combat-related pelvic fractures have high mortality rate (90.1%).⁷

With the advancement in medical technologies and modernization of the medical evacuation process during recent conflicts, orthopaedic surgeons can anticipate encountering more devastating injuries that were previously not survivable. The purpose of this study was to investigate the incidence of lower genitourinary injuries and genitourinary sequelae associated with pelvic fractures sustained in combat.

METHODS

A retrospective analysis was performed after approval by our institutional review board (blinded for purposes of review). This consisted of a systematic review of all service members who sustained a pelvic fracture during Operation Enduring Freedom and Operation Iraqi Freedom from January 1, 2008 to December 31, 2008, as previously described.⁷ The Joint Theater Trauma Registry and the Armed Forces Medical Examiner System were searched to identify survivors and nonsurvivors, respectively, with an International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9) documented pelvic fracture

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This study was conducted under a protocol reviewed and approved by the U.S. Army Medical Research and Materiel Command Institutional Review Board, and in accordance with the approved protocol.

The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or reflecting the views of the Departments of the Army, Air Force, and Defense, or the U.S. Government.

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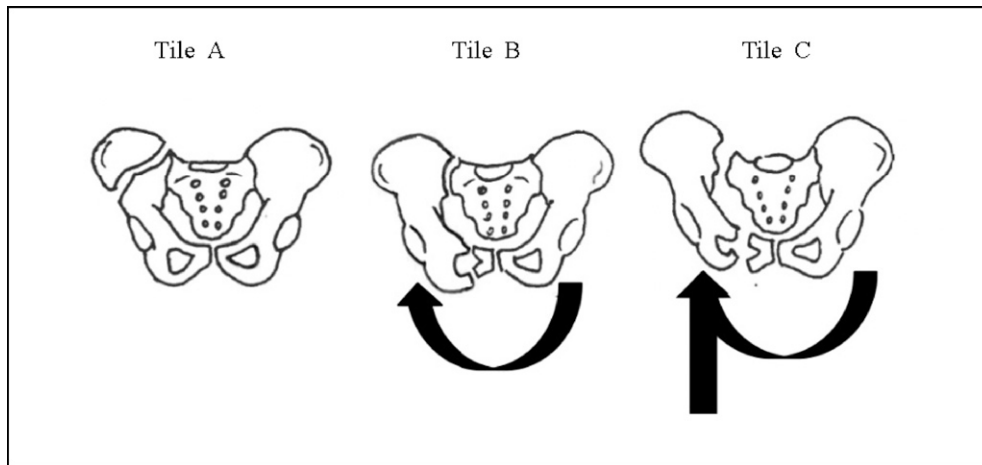


FIGURE 1. Tile classification.

from January 1 to December 31, 2008. Survivor and autopsy data consisted of imaging studies, mechanism of injury, blunt versus penetrating injury, fracture pattern, and associated organ and extremity injuries.

These records were then reviewed for associated genitourinary injuries. Survivor data were gathered from the outpatient electronic medical records, Armed Forces Health Longitudinal Technology Application, until the service member was separated from the military. Survivor data consisted of length of follow-up, prescription of urologic medications, urologic complaints, and urologic visits. Survivor and nonsurvivor data were also analyzed for concurrent lower extremity amputations, to evaluate a correlation between severe blast injury and rates of genitourinary injuries.

Genitourinary injuries were classified anatomically as bladder, vaginal, testicular, penile, or prostatic. Pelvic fractures were classified by one of the authors (J.R.H.) according to the Tile classification (Fig. 1; Table I).⁹

RESULTS

The Armed Forces Medical Examiner System database search identified 104 service members killed in action or died of wounds with a documented pelvic fracture on autopsy during the period reviewed. Thirteen were excluded because

of absence of radiographs or incorrect diagnosis, leaving 91 nonsurvivors: 90 males and 1 female. A search of the Joint Theater Trauma Registry database for the same time period yielded 12 survivors with an ICD-9 documented combat-related pelvic fracture. Two survivors were excluded secondary to incorrect diagnosis upon review of radiographs, leaving 10 survivors, all male.

Nonsurvivor Data

Among nonsurvivors, the most common mechanism of injury was an improvised explosive device (IED) blast ($n = 65$, 71%) followed by gunshot wound ($n = 8$, 9%) (Table II). This translates to 60 (66%) nonsurvivors with penetrating mechanism and 31 (34%) with a blunt mechanism. Sixty-three (69%) of the nonsurvivors were mounted when they sustained their injuries, whereas 18 (20%) were documented as dismounted.

Twenty four (26.4%) nonsurvivors sustained a Tile A pelvic fracture, 13 (14.3%) had a Tile B pelvic fracture, 51 (56%) had a Tile C, and 3 (3.3%) were unable to be classified. Thirty-nine nonsurvivors sustained a total of 59 genitourinary injuries. Injuries were categorized as bladder ($n = 22$, 37.3%), testicular ($n = 25$, 42.3%), prostatic ($n = 6$, 10.2%), and penile ($n = 6$, 10.2%) (Table III).

TABLE I. Tile Classification

Type A: Pelvic Ring Stable
A1: Fractures Not Involving the Ring
A2: Stable Minimally Displaced Fractures
Type B: Pelvic Ring Rotationally Unstable, Vertically Stable
B1: Open Book
B2: Lateral Compression, Ipsilateral
B3: Lateral Compression, Contralateral
Type C: Pelvic Ring Rotationally and Vertically Unstable
C1: Unilateral
C2: Bilateral
C3: Associated Acetabular Fracture

TABLE II. Mechanisms of Injury

Mechanism	Nonsurvivors Number (%)	Survivors Number (%)
IED	65 (71)	2 (20)
Other Explosion	5 (5)	2 (20)
Gunshot Wound	8 (9)	3 (30)
MVC Without IED	4 (4)	2 (20)
Combination	6 (6)	
Other	3 (3)	1 (10)
Total	91	10

IED, improvised explosive device; EFP, explosively formed projectile.; MVC, motor vehicle collision.

TABLE III. Distribution of Genitourinary Injuries

	Tile A	Tile B	Tile C	Unable to Classify	Total
Nonsurvivors	24	13	51	3	91
Bladder	5	3	14	—	22
Testicular	5	3	17	—	25
Prostatic	1	1	4	—	6
Penile	3	1	2	—	6
Survivors	8	—	1	1	10
Bladder	—	—	—	1	1
Testicular	—	—	—	—	—
Prostatic	1	—	—	—	1
Penile	—	—	—	—	—
Total	32	13	52	4	

TABLE IV. Genitourinary Injuries by Mechanism

	Bladder	Testicular	Prostatic	Penile
NonSurvivors	22	25	6	6
Penetrating	17	20	5	4
Blunt	5	5	1	2
Survivors	1	—	1	—
Penetrating	—	—	1	—
Blunt	1	—	—	—
Total	23	25	7	6

Of the 60 fatalities because of a penetrating mechanism, there were 46 genitourinary injuries (17 bladder [28%], 20 testicular [33%], 5 prostatic [8%], and 4 penile [7%]). Of the 31 fatalities because of a blunt mechanism, there were 13 genitourinary injuries (5 bladder [16%], 5 testicular [16%], 1 prostatic [3%] and 2 penile [6%]) (Table IV).

Twenty-two nonsurvivors (24%) sustained a lower extremity amputation in addition to their pelvic fracture, and 13 (59%) of these patients had an associated genitourinary injuries. This subset sustained a total of 21 genitourinary injuries (35% of all genitourinary injuries).

When correlating for a pelvic fracture, the majority of genitourinary injuries were associated with a Tile C fracture pattern (62.7%), whereas Tile A and Tile B accounted for 23.7% and 13.6%, respectively (Table III). The majority of bladder, testicular, and prostatic and injuries in nonsurvivors were associated with Tile C pelvic fractures (63%, 68%, and 67%, respectively).

Survivor Data

Among survivors, the most common mechanism of injury was from a blast ($n = 4$, 40%), followed by gunshot wound ($n = 3$, 30%) and vehicle collision ($n = 2$, 20%) (Table II). This translates to 5 penetrating injuries and 5 blunt injuries. Eight (80%) survivors had a documented Tile A pelvic fracture, 1 survivor had a Tile C vertical shear fracture pattern, and 1 was unclassifiable (Table III). Five of the Tile A fractures were iliac wing fractures secondary to a penetrating injury.

Two survivors (20%) sustained a genitourinary injury: 1 bladder rupture secondary to a blunt mechanism and

1 urethral/prostatic rupture secondary to a penetrating mechanism. None of the survivors with a genitourinary injury had an associated lower extremity amputation.

All survivors with a genitourinary injury as well as 2 additional survivors ($n = 4$, 40%) were being treated for erectile dysfunction at their last outpatient encounter, which was not present before their injury.

DISCUSSION

Pelvic fractures are markers of severe injury and are often associated with major intra-abdominal injuries, hemorrhage, and extremity trauma. The proximity of lower genitourinary structures with the bony pelvis makes these organs highly vulnerable to injury with pelvic fractures. It is known that patients with pelvic fractures associated with genitourinary injuries have higher rates of head injuries, longer intensive care unit and hospital stays.² This subset of patients is of great interest to the military orthopaedic community in that they require collaboration between orthopaedists, urologists, and general surgeons in both the short- and long-term management of the military casualty.

In the current study, 101 patients sustained a combat-related pelvic fracture, and 41 of these patients sustained a total of 61 genitourinary injuries. Overall, a higher incidence of genitourinary injuries was found in patients with combat-related pelvic fractures (60%) than that of their civilian counterparts (4%–15%).^{1–3} This is not surprising, given the fact that the predominant mechanism of injury of nonsurvivors was a penetrating IED blast. Injury results from both the blast wave and the penetrating fragments, which is likely to be more traumatic than the civilian injuries that are typically secondary to blunt injuries from MVCs or falls.^{4,5} Interestingly, if one considers a lower extremity traumatic amputation as a hallmark of a severe penetrating blast mechanism, the authors found that the rates of genitourinary injury were similar in casualties with and without lower extremity amputations. Sixty percent of the casualties with a lower extremity amputation sustained a genitourinary injury, whereas 67% of those without a lower extremity amputation sustained a genitourinary injury. Mossadegh et al¹⁰ found similar results when evaluating service members with blast-related perineal wounds alone compared with pelvic fractures combined with perineal wounds (72% and 69%, respectively). Current products on the market such as Blast Shorts (ArmourWorks International, Gloucester, United Kingdom) and Blast Boxers (BCB International, Cardiff, United Kingdom) may help to prevent genitourinary injuries secondary to fragmentary wounds, however there remains an equally significant number of genitourinary injuries related to the disruption of the pelvic ring.

A retrospective analysis of pelvic fractures in civilian decedents by Rittmeister et al⁴ found a statistically significant increase in abdominal injuries in those is Tile C pelvis fractures as compared to Tile A and B. Although other abdominal injuries were not the subject of the current investigation, the authors of the current study found similar results pertaining to

genitourinary injuries, with a higher incidence occurring in casualties with more severe pelvis fracture patterns (58% Tile A, 61% Tile B, 72% Tile C).

A recent retrospective study of British military casualties identified 89 service members with open blast pelvic fractures over a 2-year period. Of the 29 survivors, 28 had injuries to other organ systems and 18 had genitourinary injuries.⁸ The authors of the current study found 10 survivors with a combat-related pelvic fracture over a 1-year period; 2 of these survivors had genitourinary injuries. A higher proportion of unstable pelvic fractures found in British military survivors may account for this difference. They report almost half of the survivors had Tile B or C pelvic fractures, whereas 8 of 10 (80%) of the survivors in the current study had a Tile A pelvic fracture.

Ramasamy et al⁸ also report 6 out of 18 (33%) survivors with combat-related pelvic fractures and genitourinary injuries had ongoing genitourinary dysfunction at the time of their last follow-up at 20 months. Similarly, the authors of the current study found that both survivors with genitourinary injuries had ongoing symptoms (100%). Interestingly, 2 survivors without a documented anatomic genitourinary injury also developed symptoms of erectile dysfunction following their injury. The incidence of impotence in patients with pelvic fractures and associated urethra injuries has been described as 20%, and can be up to 30% in isolated pelvis fractures when the symptom is sought specifically.^{11,12} The pathogenesis for erectile dysfunction is multifactorial: anatomic, neurologic, vascular, and psychogenic; and requires a multidisciplinary approach to address all facets.

There are several limitations to the current study. First, it has the inherent shortcomings of a retrospective study. Second, only pelvic fractures sustained during a single year were investigated, which results in a lower number of patients. As stated earlier, this year was chosen because of completeness of medical records and autopsy data as well as availability of electronic radiographs at the time of data collection. Despite this, the high rates of genitourinary injuries sustained even in the small number of survivors (20%), and the high incidence of symptoms of erectile dysfunction following combat-related pelvic fracture (40%), highlights the importance of further investigation to minimize the long-term impact of these injuries.

With ongoing medical advances in combat casualty care, it is anticipated that there will be an increase in survival from combat-related pelvis fractures. As a result, the long-term genitourinary consequences of these injuries will likely be seen with increasing frequency. Also, the increasing number of women on the battlefield should be taken into consideration as well. Civilian literature demonstrates significant rates of dyspareunia (56%–100%) and a near 80% cesarean section rate for women who sustain a pelvis fracture and genitourinary injury.^{13–15} Continued collaboration between

orthopaedic surgeons and urologists will be needed for optimum patient care.

In summary, Tile C pelvic fractures were more common in nonsurvivors than survivors and a total of 41 patients sustained 61 genitourinary injuries. The majority of bladder, testicular, and prostatic injuries in nonsurvivors were associated with Tile C pelvic fractures (63%, 68%, and 67%, respectively). All survivors with an anatomic genitourinary injury had symptoms of erectile dysfunction at follow-up (2, 100%) and were associated with stable pelvic fractures. An additional 2 survivors had symptoms of erectile dysfunction at last follow-up despite not having an anatomic genitourinary injury.

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